Numerical approximation of granular flow in a container

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Abstract

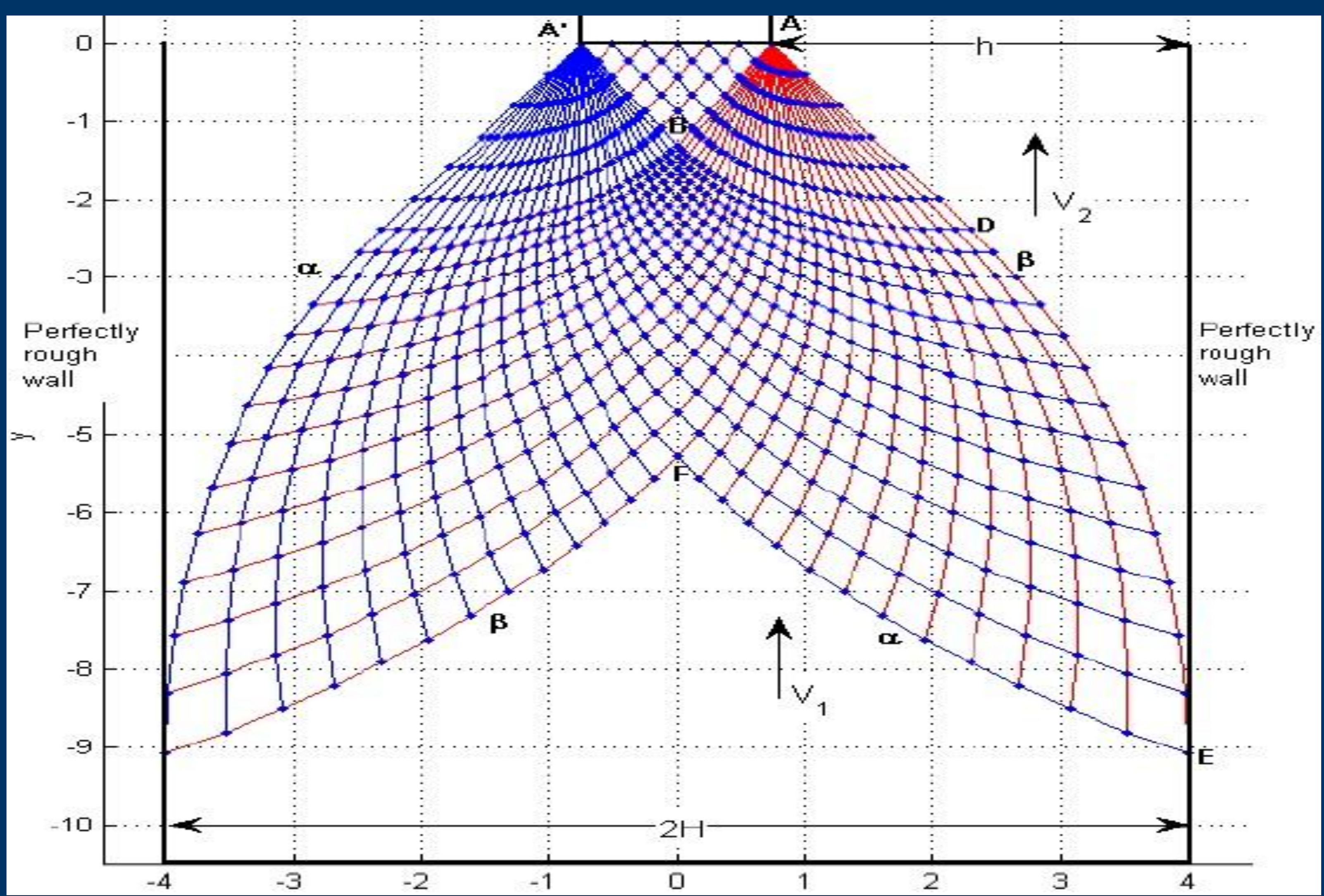
This poster presents a numerical approximation for the stress and velocity characteristics equations governing the plasticity flow of granular materials in a container satisfying the stress-equilibrium conditions, the Coulomb yield criterion and the double-slip kinematic equations.

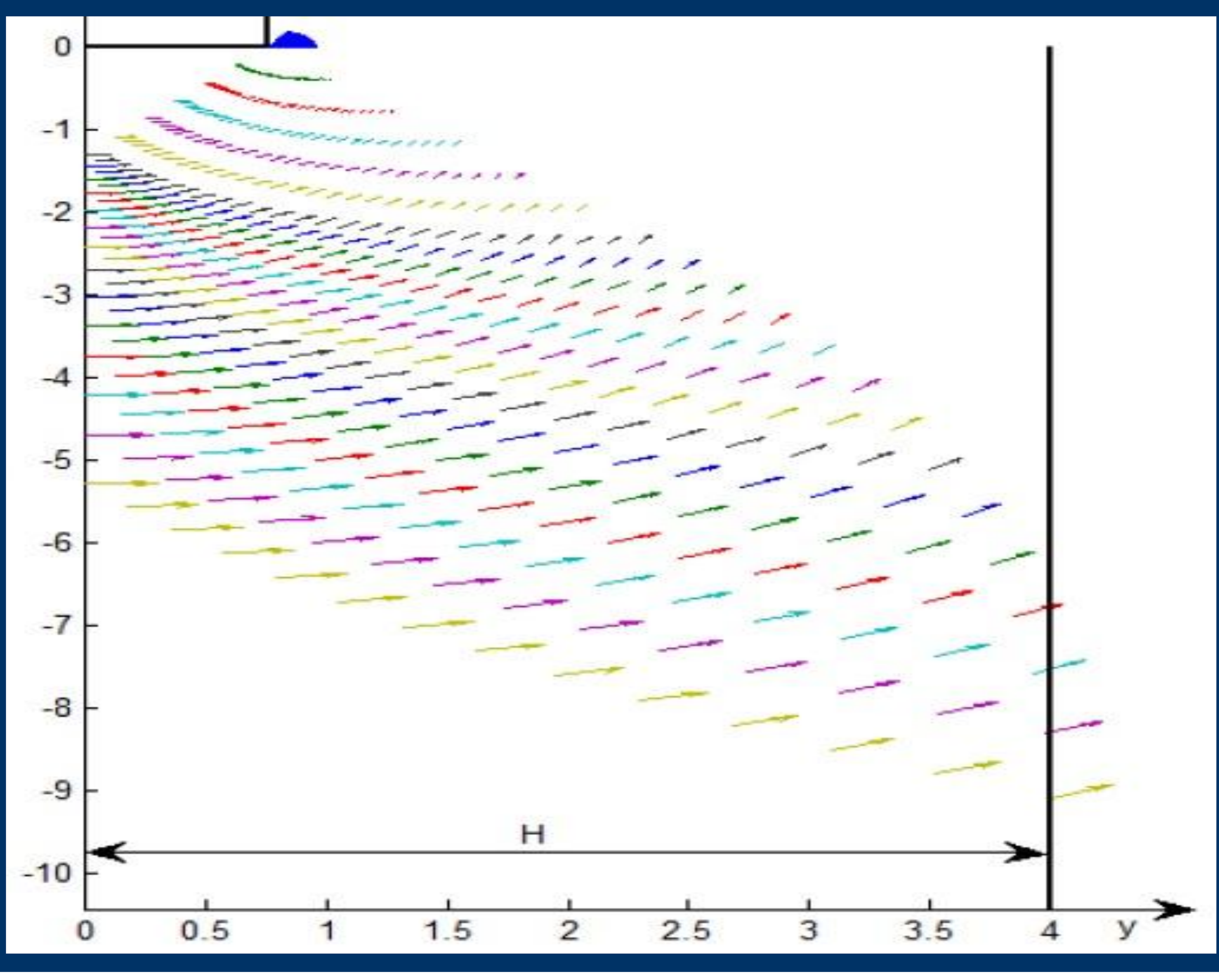
Introduction

The problem of modelling fully developed dense granular flows using continuum mechanics is complex and challenging. Stress fields within granular flows can be described by coupling the equations of linear momentum with the Coulomb–Mohr yield condition. This research is to develop a numerical method to find approximations to solutions of the double-slip model for the deformation and flow of granular materials.

Results

Indentation by a flat smooth rigid punch in a rough container wall





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Methodology

The stress relations along the characteristics are given by

$$\cos\phi\frac{\partial p}{\partial s_\alpha}+2q\frac{\partial\psi}{\partial s_\alpha}=\rho\left[X\sin(\psi+\varepsilon)-Y\cos(\psi+\varepsilon)\right],$$

$$\cos\phi\frac{\partial p}{\partial s_\beta}+2q\frac{\partial\psi}{\partial s_\beta}=\rho\left[-X\sin(\psi-\varepsilon)+Y\cos(\psi-\varepsilon)\right].$$

The kinematic relations along the characteristics are

$$\frac{\partial v_\alpha}{\partial s_\alpha}-\sin\upsilon\frac{\partial v_\beta}{\partial s_\alpha}-\Omega(\sin\phi-\sin\upsilon)\sec\phi$$

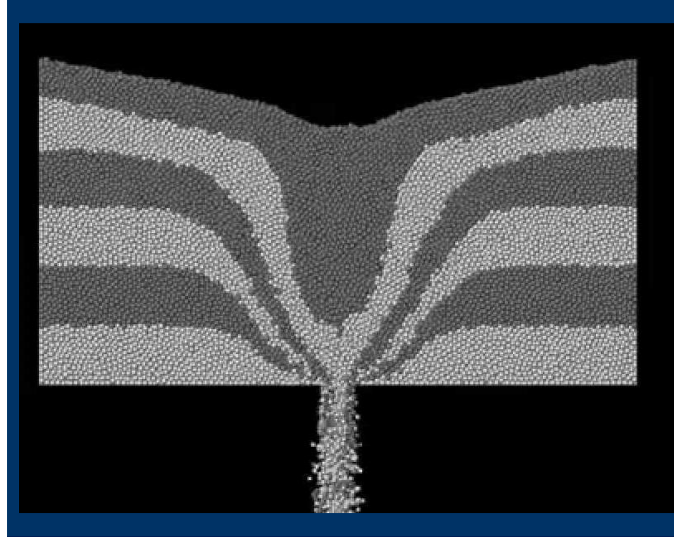
$$+\sec\phi\left[(\sin\phi-\sin\upsilon)v_\alpha+(\sin\upsilon\sin\phi-1)v_\beta\right]\frac{\partial\psi}{\partial s_\alpha}=0$$

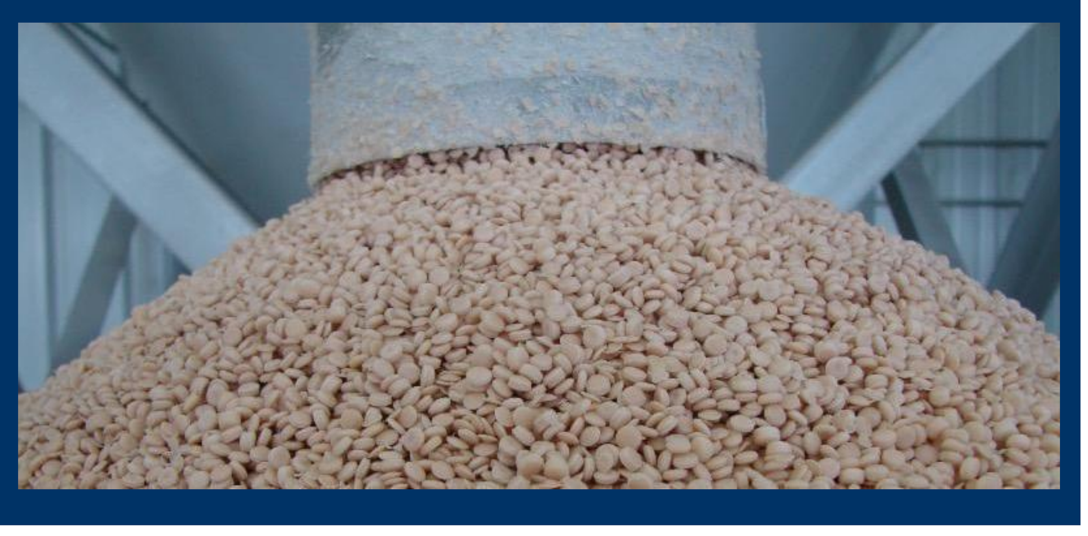
$$\frac{\partial v_\beta}{\partial s_\beta}-\sin\upsilon\frac{\partial v_\alpha}{\partial s_\beta}-\Omega(\sin\phi-\sin\upsilon)\sec\phi$$

$$-\sec\phi\left[(\sin\upsilon\sin\phi-1)v_\alpha+(\sin\phi-\sin\upsilon)v_\beta\right]\frac{\partial\psi}{\partial s_\beta}=0.$$

Applications

In the pharmaceutical and food industries, the quality of the final product depends upon complex powder or grain flow during manufacturing. Problems such as arching, ratholing, flooding and segregation can develop in equipment handling powders and grains. This research will able to account for these complicated flow issues that promises to help engineers design perfected systems for increased productivity. This could mean some major savings to the industry and could helped manufacturers optimising their production cycles. The model and computer algorithm can now predict flow paths of various grain types, which will help engineers better design chutes and troughs to prevent blockages.





References

[1] S. Alexandrov and D. Harris, Comparison of solution behaviour for three models of pressure-dependent plasticity: a simple analytical example Int. J. Mech. Sci., 48, 750-760, (2006).

[2] S. Alexandrov and D. Harris, An exact solution for a model of pressure-dependent plasticity in an un-steady plane strain process European Journal of Mechanics A/Solids, 29, 966-975 (2010).

Further Information:

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